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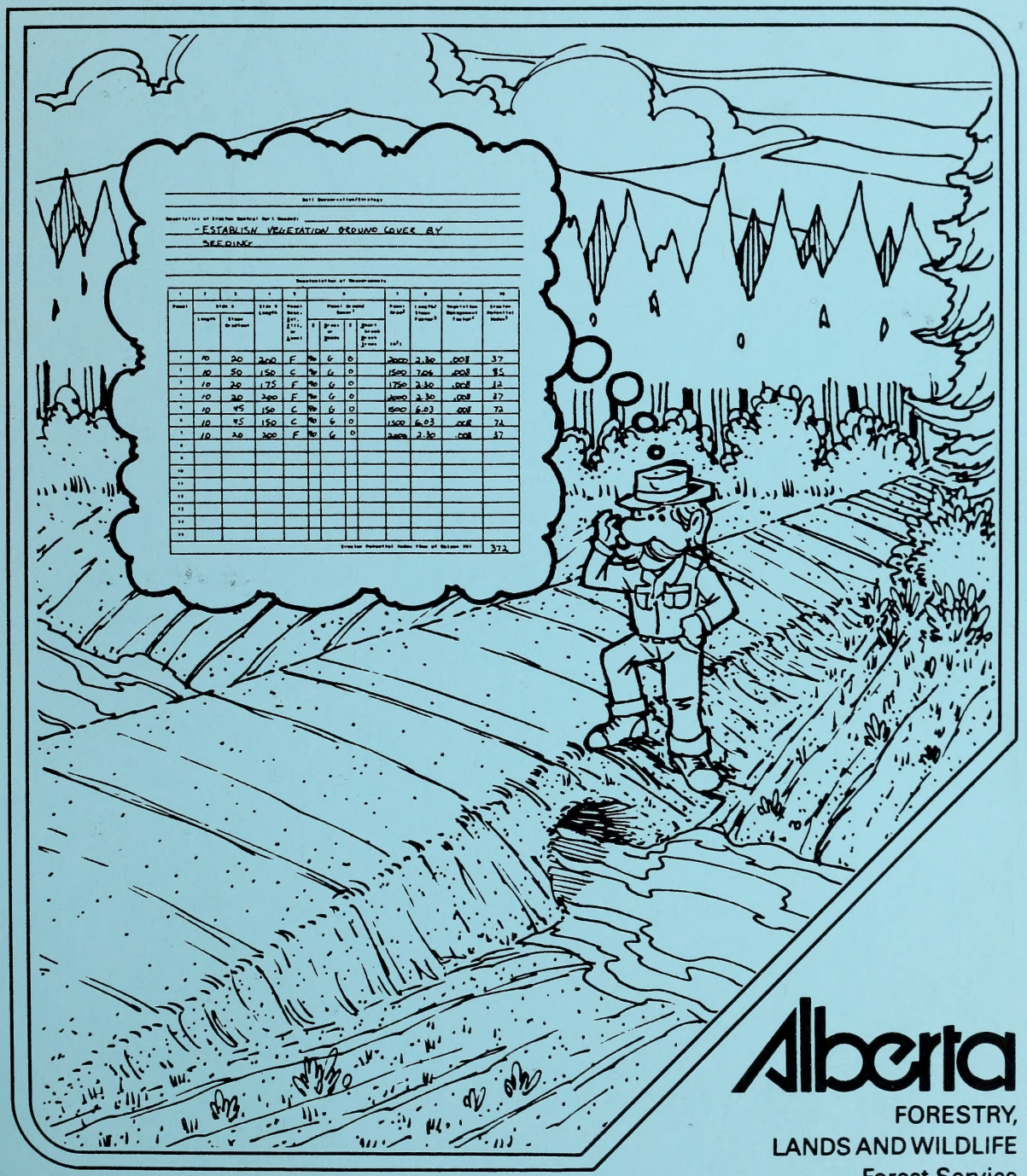
Erosion Potential Index

A Method for Evaluating Sheet Erosion at Stream Crossings



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EROSION POTENTIAL INDEX

A Method for Evaluating Sheet Erosion at Stream Crossings

by

Phillip Anderson

and

Robert Anderson

1987
Edmonton

Alberta
Forestry, Lands and Wildlife

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1. INTRODUCTION

Soil conservation is a primary role of a watershed manager. Soil lost through erosion can end up in a stream, causing lowered water quality and loss of fish habitat. Most soil erosion problems in forested areas are associated with linear disturbances at stream crossings. Crossings for roads, pipelines and seismic lines are responsible for as much as 90% of the sedimentation of streams caused by forest land use (Anderson et al. 1976).

This manual provides a structured, easy to use method of evaluating stream crossings with the intent of:

1. reducing the amount of sediment entering streams, and
2. being more cost effective in the use of resources for reclamation.

1.1 What is an Erosion Potential Index?

An Erosion Potential Index (EPI) is a numerical representation of the relative potential for sheet erosion at a stream crossing based on the Modified Soil Loss Equation (Warrington et al 1980). For Alberta conditions, it was found that the most sensitive factors in this equation were slope gradient, slope length, disturbed area and vegetation cover. The EPI is therefore based on these factors.

The EPI is a numerical index value. The higher the index, the greater potential for erosion on the site. Soil conservation strategies can then be worked out by manipulating the factors until there is an acceptable index.

1.2 Use of Manual

This manual describes how to use the EPI to determine the potential for erosion at a given site. This information may be used to see if the crossing requires additional mitigative work.

The manual outlines vegetation management strategies which may be employed to reduce erosion at a crossing. Examples are given which show how the EPI may be used to determine which portions of the crossing require additional mitigative work and what impact that work will have in reducing potential sedimentation problems. Cost/benefit analyses are provided for the various vegetation management strategies.

The EPI may also be used as a tool to compare proposed stream crossing alternatives. Comparisons would require that submitted plans have sufficient detail for the analysis. An EPI should be conducted in those cases where erosion potential is expected to be high, based on experience in the area.

1.3 How is an EPI Completed?

There are four steps in completing an EPI:

1. The on-site evaluation - measurements of slope angle, slope length, area and percent vegetation cover are made at the stream crossing.
2. Determining the EPI - measurements are used in calculating the EPI value.
3. Implementation of the EPI - the EPI can be used to determine if reclamation work is necessary and evaluate erosion control strategies.
4. Strategies for reducing erosion potential - the EPI can be used to devise an erosion control strategy for the stream crossing if additional mitigative work is required.

2. THE ON-SITE EVALUATION

2.1 What Parameters are Measured on Site?

Use of this method requires measurements of four physical parameters - disturbed area, slope gradient, slope length and an estimate of vegetation ground cover. An index value is computed from these measurements which ranks the relative level of erodibility of a stream crossing site.

2.2 When Should the Crossing be Measured?

The on-site evaluation should be carried out while the site is free of snow cover. The EPI is best measured when vegetation cover has reached its maximum growth for the season.

2.3 Tools Required to Complete the Measurement

Few tools are required to measure the EPI parameters. Use a Topofil or topographic chain to obtain a measure of area and slope length. Use a clinometer to measure the slope gradient. Have a calculator handy to compute the EPI value while still at the site. Use the field worksheets provided at the back of the manual to record all pertinent information.

2.4 How to Measure the Crossing

1. Consider the crossing divided into quadrants. A quadrant begins at the stream and road intersection and extends uphill, paralleling the road to the break in slope or to an effective cross-ditch which adequately diverts water off the right-of-way (Figure 1). Within each quadrant a series of panels are measured. A panel is an area of similar profile and vegetation cover, roughly rectangular in shape and usually adjacent to the road. In each panel measure area, slope gradient, slope length and vegetation ground cover (Figure 2).

2. Determine the direction of sheet erosion on the panel profile and set this direction as side A. Sheet erosion commonly occurs perpendicular to the road alignment such as on hillside cuts and fills. If the road is along a hillside cut, then slope length and gradient are measured from the centre of the ditch line to the top of the embankment opposite the road surface (Figure 2). However, if the road is fill material across a valley, then side A is measured from the edge of the road surface down to the centre of the ditch line (Figure 3).

In some cases the crossing may be quite level without cuts and fills and the majority of sheet erosion occurs parallel to the linear disturbance. An example is a pipeline crossing. The slope length and gradient of side A is then measured in the same direction as the pipeline from the creek to the break in slope or to an effective crossditch (Figure 4). When in doubt which is side A, determine the length/slope factor for both sides: the side with the highest length/slope factor is always side A.

3. Record the length of side A in metres and its slope gradient in percent.

4. Measure the length of the side perpendicular to side A and designate it as side B (Figure 2).

5. Finally, to complete the evaluation of this panel, estimate vegetation ground cover to the nearest five percent.

6. Use the back of the field worksheet to sketch a diagram of panel locations.

7. Continue the evaluation of panels until all four quadrants have been considered. Check that the field worksheet contains side A and side B measurements, panel descriptions and ground cover estimates for all panels measured. Ensure that a complete sketch is drawn on the back of the worksheet.

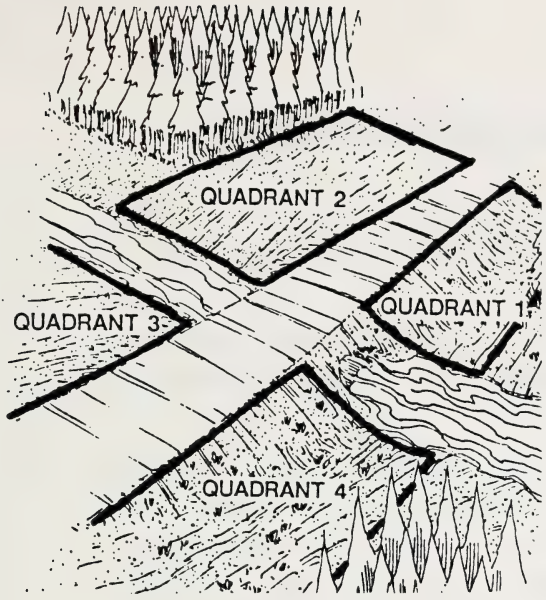

Figure 1. Stream crossing showing quadrant locations.

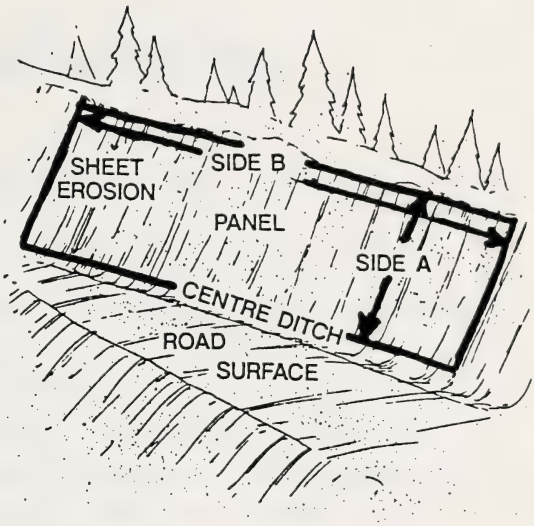

Figure 2. Hillside road cut showing panel location.

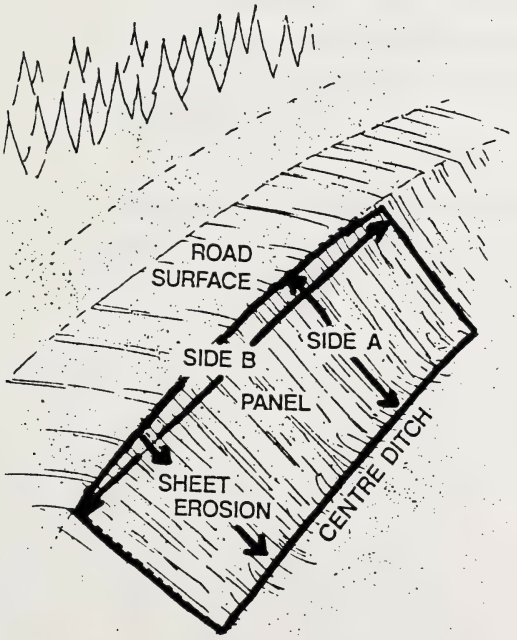

Figure 3. Road fill showing panel location.

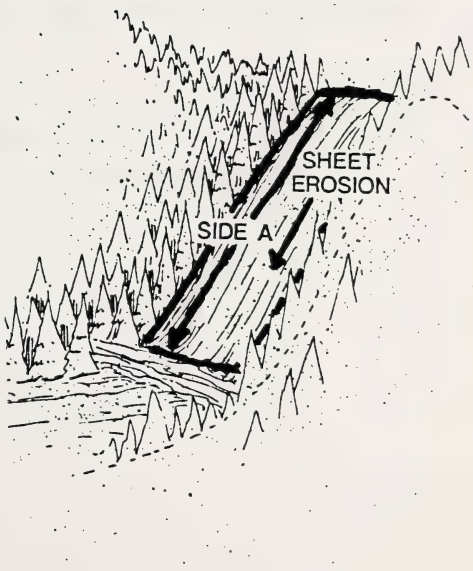

Figure 4. Stream crossing without slope cuts and fills.

3. DETERMINING THE EROSION POTENTIAL INDEX

Compute the index value using the following steps.

1. Calculate Panel Area:
   Panel Area = Side A x Side B (Col. 2 x Col. 4 on worksheet)

2. Determine the length/slope (L/S) factor (Appendix A):
   This factor is determined for side A using its length and slope gradient (Cols. 2 & 3), and finding the corresponding values in Appendix A. If the values are not listed in Appendix A, round to the nearest whole number or use straight line interpolation.

3. Determine the vegetation management (V/M) factor (Appendix B): Use the ground cover estimate and vegetation type (Col. 6) to establish the vegetation management factor. Newly constructed crossings will not have a canopy. Therefore, use only the factors in the first two rows of the table in Appendix B.

4. Compute the Erosion Potential Index:
   EPI = Panel Area x L/S Factor x V/M Factor.
   (Col. 7 x Col. 8 x Col. 9)

4. IMPLEMENTATION OF THE EROSION POTENTIAL INDEX

4.1 How to Use the EPI Values

The EPI values can be used in determining the magnitude of the erosion potential at a given site. As the EPI increases, the potential for stream sedimentation also increases. Table 1 shows how to interpret the EPI in terms of the severity of potential erosion at a given crossing.

Table 1. Suggested interpretation of EPI Values

EPI	Interpretation
0 - 500	Very good crossing, no additional mitigative work generally required.
501 - 2 000	May be acceptable for a new crossing (<3 yrs.), usually unacceptable for an old crossing.
2 000 - 15 000	Unacceptable, erosion control work is needed.
15 001+	Poor crossing, immediate erosion control is needed.

4.2 Steps to Implement Erosion Control Work

1. The first step is to determine the EPI. If there is a serious erosion problem, this information could provide strong support in getting the site reclaimed. While on site, establish what erosion control work will be required to lower the EPI to an acceptable range. Chapter 5 gives examples of how this may be done.

2. A letter can now be sent to the company describing the problem and, in general terms, what work needs to be done. Priority should be given to crossings with the highest EPI. Generally, letters are sent out for crossings with an EPI greater than 2 000.

3. Site inspection should be completed shortly after the company has completed the erosion control work. Another EPI should be done at that time. If the EPI is lower than 500 a letter can be sent to the company stating that the crossing is now acceptable. (This does not preclude erosion work that may be needed in the future). Usually a second inspection will be required the following year to determine if vegetation cover has been established.

4. A second letter should be sent if the company did not comply with the erosion work required, or after one growing season the vegetation is not established so as to lower the EPI to a level below 500.

5. A reclamation order may be considered after two letters have been sent and the company has failed to complete the erosion work satisfactorily.

5. STRATEGIES FOR REDUCING EROSION POTENTIAL

5.1 Overview of Erosion Potential Reduction Strategies

Managing the slope angle, length of slope, area disturbed and amount of vegetation cover is the most effective way of controlling sheet erosion. There are other factors which contribute to the amount of erosion coming off a slope, but these are difficult or impossible to manage. It is easy to imagine how difficult it would be to manage the amount of rain which lands on a slope, or change the soil texture. Table 2 outlines common techniques used to control the amount of erosion.

The EPI may be used to evaluate the effectiveness of different soil conservation strategies. This is done by recalculating the EPI assuming various erosion controls exist, i.e. vegetation cover, cross ditches, etc. Space is provided for this on the back of the worksheet. Complete the evaluation while on site so that berms, ditches, culverts etc. can be visualized in their most effective locations.

5.2 Examples of Erosion Potential Reduction Strategies

Four scenarios are presented in the following section which describe soil conservation strategies and show their effectiveness in terms of erosion control and cost. The examples are drawn from a newly constructed road crossing which lacks erosion control measures (Figure 5). The crossing has no vegetation ground cover or water diversion devices resulting in an EPI ranking of 20 927 (Figure 6).

Table 2

Preventive and mitigative strategies to prevent erosion

(Adapted from Warrington et al 1980)

Erodibility Factor	Preventive	Mitigative
Snowmelt	Where soils have high erodibility factors, plan silvicultural activities favorable to snow retention. Maintain as much shaded area as possible.	Reduce snowmelt runoff rates by intercepting the solar energy above the snow surface.
Soil Erodibility	Maintain soil permeability, structure and organic matter content. Compaction should be avoided.	Increase long-term organic matter content, in the soil by promoting vegetative growth. This can have positive benefits on structure and permeability as well.
Length of Slope	Control location and design of various types of construction to avoid creating long cut and/or fill slopes, large landings and extensive activity areas.	Locate diversions, such as terraces, to reduce the distance water can move uninterrupted over land.
Slope Angle	Control location and design of construction on steep slopes, following contours where possible.	Reduce steep slopes created by construction by placing soil and rock at the base of cuts.
Vegetation Cover	Minimize forest floor destruction and maintain understory canopy, especially where surface residues are lacking. A high overstory canopy may accelerate raindrop splash erosion when the forest floor has been destroyed. An example of this might be a campground with little or no surface residue.	Establish vegetation, or use other methods such as addition of mulch or chemical binders to achieve acceptable levels of soil loss. Various mechanical methods may be used to create surface roughness or small diversions (e.g. site preparation along the contour rather than up and down the slope. Wetting agents may be used to correct hydrophobic conditions.

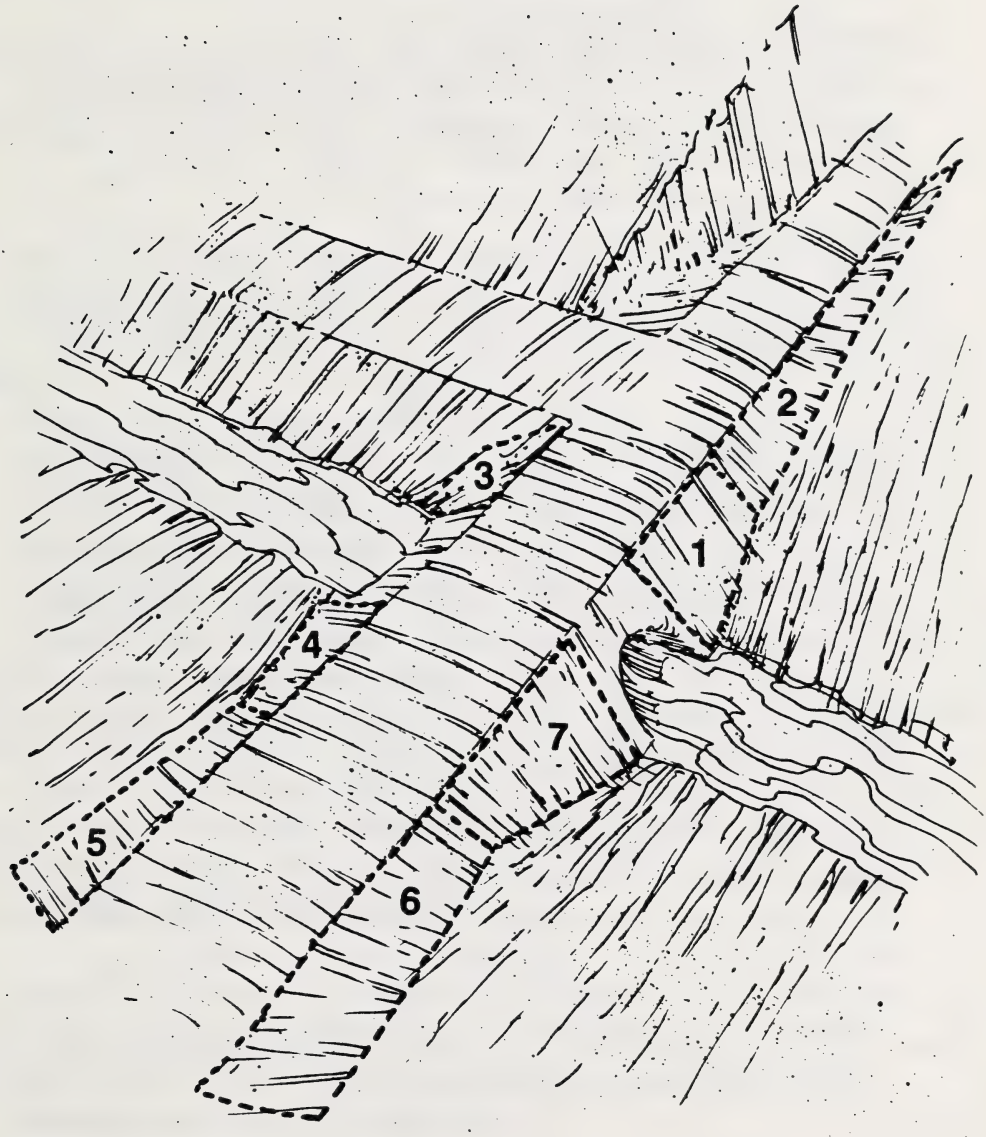

Figure 5. Stream crossing without erosion control measures.

EROSION POTENTIAL INDEX WORKSHEET

Road Location and Description

Ranger District: DH 1

Legal Location: L.S.D. 4 Section: 9 Township: 38 Range: 8 W 5 M

Disposition Number: LOG 860512

Constructed by: CONSTRUCTION CO.

Maintained by: ROAD MAINTENANCE SERVICE

Creek/River Name: TYPICAL CREEK

Other Description: LOCAL NAME FOR ROAD

Assessment Details

Erosion Potential Index: (Total of Column 10) 20927

Date of Survey: (Y/M/D) 86 / 09 / 05

Conducted by: WHOEVER

Photos Available: Yes _____ No ✓

Measurements and Calculations

1	2	3	4	5	6				7	8	9	10
Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2] (m^2)	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
	Length	Slope Gradient			%	Grass or Weeds	%	Short brush Brush Trees				
1	10	20	200	F	0		0		2000	2.30	.450	2070
2	10	50	150	C	0		0		1500	7.06	.450	4766
3	10	20	175	F	0		0		1750	2.30	.450	1811
4	10	20	200	F	0		0		2000	2.30	.450	2070
5	10	45	150	C	0		0		1500	6.03	.450	4070
6	10	45	150	C	0		0		1500	6.03	.450	4070
7	10	20	200	F	0		0		2000	2.30	.450	2070
8												
9												
10												
11												
12												
13												
14												
15												
Erosion Potential Index (Sum of Column 10)												20927

NOTE: Abbreviations used: m = metres; m^2 = square metres; % = percent; Desc. = Description

[1] If a portion of the panel surface has a canopy of brush or trees, refer to Table 2 for additional details.

[2] Panel Area is calculated by multiplying Side A Length and Side B Length.

[3] Length/Slope Factor is taken directly from Table 1 using the measurements of Side A.

[4] Vegetation Management Factor is taken directly from Table 2 using ground cover percentage and vegetation type.

[5] Erosion Potential Index is calculated by multiplying Columns 7, 8 and 9.

Figure 6. Example EPI worksheet without erosion prevention measures.

5.21 Strategy 1: Vegetation Management

The Figure 7 shows the EPI resulting from increased vegetation cover. Grass cover is raised from zero to 90 percent resulting in an EPI of 372.

An acceptable grass cover can be achieved by hydroseeding at a cost of approximately $700 (including materials, equipment and operator). Alternatively, hand seeding may be completed at a cost of approximately $400.

The cost effectiveness of both methods can be rated according to the change in EPI per dollars spent. Hand seeding is the most cost effective if a grass cover can be established in the same number of trials as hydroseeding.

EPI reduction per dollar spent for:

Hand seeding

20 927 - 372 = 20 555 / $400 = 51 (EPI values) / $

Hydroseeding

20 927 - 372 = 20 555 / $700 = 29 (EPI values) / $

5.22 Strategy 2: Area Management

Another method to reduce the EPI is by installing berms, cross-ditches, culverts etc. These devices will prevent sediment on the right-of-way from entering the stream and reduce the area contributing to the EPI. By installing proper cross-ditching, panels 2, 5 and 6 are eliminated (Figure 8). Total area is reduced by 4 500 m^2 with an EPI of 6 221.

The cost effectiveness is very high because the construction of berms and cross-ditches is completed inexpensively with a small crawler tractor. The work will cost approximately $250.

EPI reduction per dollar spent for:

Berm Construction

20 927 - 6 221 = 14 706 / $250 = 59 / $

In this case cost effectiveness is not the only consideration. The EPI is not yet low enough to consider erosion control work completed. Additional vegetation cover is needed.

Soil Conservation/Strategy

Description of Erosion Control Work Needed:

-ESTABLISH VEGETATION GROUND COVER BY SEEDING

Recalculation of Measurements

1	2	3	4	5	6				7	8	9	10
Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2] (m^2)	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
	Length	Slope Gradient			%	Grass or Weeds	%	Short brush Brush Trees				
1	10	20	200	F	90	G	0		2000	2.30	.008	37
2	10	50	150	C	90	G	0		1500	7.06	.008	85
3	10	20	175	F	90	G	0		1750	2.30	.008	32
4	10	20	200	F	90	G	0		2000	2.30	.008	37
5	10	45	150	C	90	G	0		1500	6.03	.008	72
6	10	45	150	C	90	G	0		1500	6.03	.008	72
7	10	20	200	F	90	G	0		2000	2.30	.008	37
8												
9												
10												
11												
12												
13												
14												
15												
Erosion Potential Index (Sum of Column 10)												372

Sketch of Area

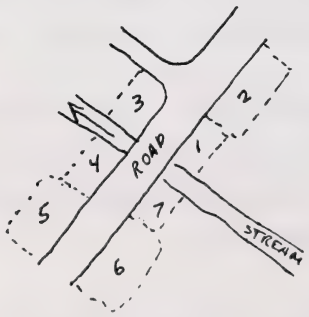

Figure 7. Example EPI calculation using vegetation management strategy.

Soil Conservation/Strategy

Description of Erosion Control Work Needed:

-REDUCE AREA CONTRIBUTING SEDIMENT TO CREEK BY INSTALLING CROSS-DITCHES BELOW PANELS 2, 5 AND 6.

Recalculation of Measurements

1	2	3	4	5	6				7	8	9	10
Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2] (m^2)	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
	Length	Slope Gradient			%	Grass or Weeds	%	Short brush Brush Trees				
1	10	20	200	F	0				2000	2.30	.450	2070
2												
3	10	20	175	F	0				1750	2.30	.450	1811
4	10	20	200	F	0				2000	2.30	.450	2070
5												
6												
7	10	20	200	F	0				2000	2.30	.450	2070
8												
9												
10												
11												
12												
13												
14												
15												
Erosion Potential Index (Sum of Column 10)												6221

Sketch of Area

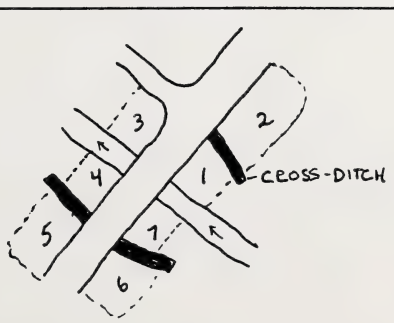

Figure 8. Example EPI calculation using area management strategy.

5.23 Strategy 3: Area and Vegetation Management

A highly recommended strategy is to use both area and vegetation management to lower the EPI. Adding a 90 percent grass catch to the example crossing with berms installed will lower the EPI to 143 (Figure 9). This strategy reduces the EPI to the greatest extent, while remaining cost effective.

EPI reduction per dollar spent for:

Hand seeding and berm construction

20 927 - 143 = 20 784 / $650 = 32 / $

Hydroseeding and berm construction

20 927 - 143 = 20 784 / $950 = 22 / $

5.24 Strategy 4: Length/Slope Management

It is possible to change the length and slope of hillside cuts in an effort to lower the EPI. However, the result of recontouring does not improve the EPI ranking. This is because reducing slope gradient increases slope length and area.

Figure 10 shows that for all slope gradients reduced, slope lengths are increased. The result is increased panel area exposed to sheet erosion. The EPI is raised to 24 528. It is pointless to carry out recontouring work when the result is a higher EPI.

Soil Conservation/Strategy

Description of Erosion Control Work Needed:

- ESTABLISH VEGETATION COVER BY SEEDING AND REDUCE AREA CONTRIBUTING SEDIMENT TO CREEK BY INSTALLING CROSS-DITCHES BELOW PANELS 2, 5 AND 6.

Recalculation of Measurements

1	2	3	4	5	6				7	8	9	10
Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2] (m^2)	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
	Length	Slope Gradient			$	Grass or Weeds	$	Short brush Brush Trees				
1	10	20	200	F	90	G	0		2000	2.30	.008	37
2												
3	10	20	175	F	90	G	0		1750	2.30	.008	32
4	10	20	200	F	90	G			2000	2.30	.008	37
5												
6												
7	10	20	200	F	90	G	0		2000	2.30	.008	37
8												
9												
10												
11												
12												
13												
14												
15												
Erosion Potential Index (Sum of Column 10)												143

Sketch of Area

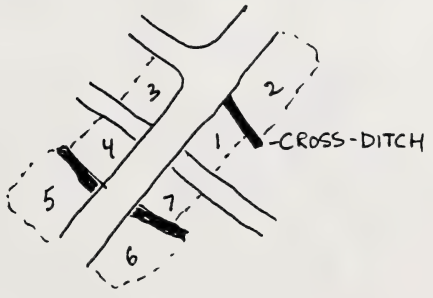

Figure 9. Example EPI calculation using vegetation management and area management strategy.

Soil Conservation/Strategy

Description of Erosion Control Work Needed:

- REDUCE SLOPE GRADIENTS BY RECONTOURING

Recalculation of Measurements

1	2	3	4	5	6				7	8	9	10
Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2] (m^2)	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
	Length	Slope Gradient			%	Grass or Weeds	%	Short brush Brush Trees				
1	20	10	200	F	0		0		4000	1.10	.450	1980
2	20	25	150	C	0		0		3000	4.70	.450	6345
3	20	10	175	F	0		0		3500	1.10	.450	1733
4	20	10	200	F	0		0		4000	1.10	.450	1980
5	22.5	20	150	C	0		0		3375	3.46	.450	5255
6	22.5	20	150	C	0		0		3375	3.46	.450	5255
7	20	10	200	F	0		0		4000	1.10	.450	1980
8												
9												
10												
11												
12												
13												
14												
15												
Erosion Potential Index (Sum of Column 10)												24528

Sketch of Area

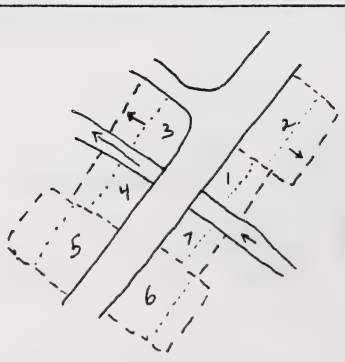

Figure 10. Example EPI calculation using length/slope management strategy.

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Length(m)	Slope (%)																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	25	30	33.3	35	40	45	50	66.6	100	150	200
1	0.02	0.03	0.05	0.07	0.09	0.12	0.14	0.17	0.21	0.24	0.28	0.32	0.36	0.41	0.45	0.50	0.56	0.61	0.67	0.73	1.05	1.41	1.68	1.82	2.25	2.70	3.16	4.70	7.40	10.0	11.4
2	0.03	0.05	0.07	0.10	0.13	0.17	0.20	0.25	0.29	0.34	0.40	0.45	0.51	0.58	0.64	0.71	0.79	0.87	0.95	1.03	1.48	2.00	2.37	2.57	3.18	3.81	4.47	6.64	10.4	14.1	16.1
3	0.04	0.06	0.09	0.12	0.16	0.20	0.25	0.30	0.36	0.42	0.49	0.56	0.63	0.71	0.79	0.88	0.97	1.06	1.16	1.26	1.82	2.45	2.91	3.15	3.89	4.67	5.47	8.14	12.8	17.3	19.8
4	0.04	0.07	0.11	0.14	0.19	0.24	0.29	0.35	0.42	0.49	0.56	0.64	0.73	0.82	0.91	1.01	1.12	1.23	1.34	1.46	2.10	2.83	3.36	3.64	4.50	5.40	6.32	9.40	14.8	20.0	22.8
5	0.05	0.08	0.12	0.16	0.21	0.27	0.33	0.39	0.47	0.55	0.63	0.72	0.81	0.92	1.02	1.13	1.25	1.37	1.50	1.63	2.35	3.17	3.75	4.07	5.03	6.03	7.06	10.5	16.5	22.4	25.5
6	0.06	0.09	0.13	0.18	0.23	0.29	0.36	0.43	0.51	0.60	0.69	0.79	0.89	1.00	1.12	1.24	1.37	1.50	1.64	1.78	2.57	3.47	4.11	4.46	5.51	6.61	7.74	11.5	18.1	24.5	28.0
7	0.06	0.10	0.14	0.19	0.25	0.32	0.39	0.47	0.55	0.65	0.75	0.85	0.96	1.08	1.21	1.34	1.48	1.62	1.77	1.93	2.78	3.75	4.44	4.81	5.95	7.14	8.36	12.4	19.5	26.5	30.2
8	0.07	0.10	0.15	0.21	0.27	0.34	0.41	0.50	0.59	0.69	0.80	0.91	1.03	1.16	1.29	1.43	1.58	1.74	1.90	2.06	2.97	4.01	4.75	5.15	6.36	7.63	8.94	13.2	20.9	28.3	32.3
9	0.07	0.11	0.16	0.22	0.28	0.36	0.44	0.53	0.63	0.73	0.85	0.97	1.09	1.23	1.37	1.52	1.68	1.84	2.01	2.19	3.15	4.25	5.04	5.46	6.75	8.10	9.48	14.1	22.2	30.0	34.3
10	0.07	0.12	0.17	0.23	0.30	0.38	0.46	0.56	0.66	0.77	0.89	1.02	1.15	1.30	1.45	1.60	1.77	1.94	2.12	2.30	3.32	4.48	5.31	5.76	7.11	8.53	9.99	14.8	23.4	31.6	36.1
11	0.08	0.12	0.18	0.24	0.31	0.40	0.49	0.59	0.69	0.81	0.94	1.07	1.21	1.36	1.52	1.68	1.86	2.04	2.22	2.42	3.49	4.70	5.57	6.04	7.46	8.95	10.4	15.5	24.5	33.2	37.9
12	0.08	0.13	0.19	0.25	0.33	0.41	0.51	0.61	0.73	0.85	0.98	1.12	1.26	1.42	1.59	1.76	1.94	2.13	2.32	2.53	3.64	4.91	5.82	6.30	7.79	9.35	10.9	16.2	25.6	34.7	39.6
13	0.08	0.13	0.19	0.26	0.34	0.43	0.53	0.64	0.76	0.88	1.02	1.16	1.32	1.48	1.65	1.83	2.02	2.21	2.42	2.63	3.79	5.11	6.06	6.56	8.11	9.73	11.3	16.9	26.6	36.1	41.2
14	0.09	0.14	0.20	0.27	0.36	0.45	0.55	0.66	0.78	0.92	1.06	1.21	1.37	1.54	1.71	1.90	2.09	2.30	2.51	2.73	3.94	5.31	6.29	6.81	8.42	10.1	11.8	17.5	27.6	37.4	42.8
15	0.09	0.14	0.21	0.28	0.37	0.46	0.57	0.69	0.81	0.95	1.09	1.25	1.41	1.59	1.77	1.97	2.17	2.38	2.60	2.82	4.07	5.49	6.51	7.05	8.71	10.4	12.2	18.2	28.6	38.8	44.3
16	0.09	0.15	0.22	0.29	0.38	0.48	0.59	0.71	0.84	0.98	1.13	1.29	1.46	1.64	1.83	2.03	2.24	2.46	2.68	2.92	4.21	5.67	6.72	7.28	9.00	10.8	12.6	18.8	29.6	40.0	45.7
17	0.10	0.15	0.22	0.30	0.39	0.49	0.61	0.73	0.86	1.01	1.16	1.33	1.51	1.69	1.89	2.09	2.31	2.53	2.76	3.01	4.34	5.85	6.93	7.51	9.28	11.1	13.0	19.3	30.5	41.3	47.1
18	0.10	0.16	0.23	0.31	0.40	0.51	0.62	0.75	0.89	1.04	1.20	1.37	1.55	1.74	1.94	2.15	2.38	2.61	2.85	3.09	4.46	6.02	7.13	7.72	9.55	11.4	13.4	19.9	31.3	42.5	48.5
19	0.10	0.16	0.24	0.32	0.42	0.52	0.64	0.77	0.91	1.07	1.23	1.41	1.59	1.79	2.00	2.21	2.44	2.68	2.92	3.18	4.59	6.18	7.32	7.93	9.81	11.7	13.7	20.4	32.2	43.6	49.8
20	0.11	0.17	0.24	0.33	0.43	0.54	0.66	0.79	0.94	1.10	1.26	1.44	1.63	1.84	2.05	2.27	2.50	2.75	3.00	3.26	4.70	6.34	7.51	8.14	10.0	12.0	14.1	21.0	33.0	44.8	51.1
21	0.11	0.17	0.25	0.34	0.44	0.55	0.67	0.81	0.96	1.12	1.30	1.48	1.67	1.88	2.10	2.33	2.57	2.81	3.07	3.34	4.82	6.50	7.70	8.34	10.3	12.3	14.4	21.5	33.9	45.9	52.4
22	0.11	0.18	0.25	0.34	0.45	0.56	0.69	0.83	0.98	1.15	1.33	1.51	1.71	1.93	2.15	2.38	2.63	2.88	3.15	3.42	4.93	6.65	7.88	8.54	10.5	12.6	14.8	22.0	34.7	46.9	53.6
23	0.11	0.18	0.26	0.35	0.46	0.58	0.71	0.85	1.01	1.17	1.36	1.55	1.75	1.97	2.20	2.44	2.69	2.95	3.22	3.50	5.05	6.80	8.06	8.73	10.7	12.9	15.1	22.5	35.4	48.0	54.8
24	0.12	0.18	0.27	0.36	0.47	0.59	0.72	0.87	1.03	1.20	1.38	1.58	1.79	2.01	2.24	2.49	2.74	3.01	3.29	3.57	5.15	6.95	8.23	8.92	11.0	13.2	15.4	23.0	36.2	49.0	56.0
25	0.12	0.19	0.27	0.37	0.48	0.60	0.74	0.89	1.05	1.23	1.41	1.61	1.83	2.05	2.29	2.54	2.80	3.07	3.35	3.65	5.26	7.09	8.40	9.10	11.2	13.5	15.8	23.5	37.0	50.0	57.2
26	0.12	0.19	0.28	0.37	0.49	0.61	0.75	0.90	1.07	1.25	1.44	1.65	1.86	2.09	2.34	2.59	2.86	3.13	3.42	3.72	5.36	7.23	8.57	9.28	11.4	13.7	16.1	23.9	37.7	51.0	58.3
27	0.12	0.20	0.28	0.38	0.50	0.62	0.77	0.92	1.09	1.27	1.47	1.68	1.90	2.13	2.38	2.64	2.91	3.19	3.49	3.79	5.47	7.37	8.73	9.46	11.6	14.0	16.4	24.4	38.4	52.0	59.4
28	0.13	0.20	0.29	0.39	0.50	0.64	0.78	0.94	1.11	1.30	1.50	1.71	1.93	2.17	2.42	2.69	2.96	3.25	3.55	3.86	5.57	7.51	8.89	9.63	11.9	14.2	16.7	24.8	39.1	53.0	60.5
29	0.13	0.20	0.29	0.40	0.51	0.65	0.79	0.96	1.13	1.32	1.52	1.74	1.97	2.21	2.47	2.74	3.02	3.31	3.61	3.93	5.67	7.64	9.05	9.80	12.1	14.5	17.0	25.3	39.8	53.9	61.6
30	0.13	0.21	0.30	0.40	0.52	0.66	0.81	0.97	1.15	1.34	1.55	1.77	2.00	2.25	2.51	2.78	3.07	3.37	3.67	4.00	5.76	7.77	9.20	9.97	12.3	14.7	17.3	25.7	40.5	54.8	62.6
31	0.13	0.21	0.30	0.41	0.53	0.67	0.82	0.99	1.17	1.36	1.57	1.80	2.04	2.29	2.55	2.83	3.12	3.42	3.74	4.06	5.86	7.90	9.36	10.1	12.5	15.0	17.6	26.1	41.2	55.7	63.7
32	0.14	0.21	0.31	0.42	0.54	0.68	0.83	1.00	1.19	1.39	1.60	1.83	2.07	2.32	2.59	2.87	3.17	3.48	3.80	4.13	5.95	8.02	9.51	10.3	12.7	15.2	17.8	26.5	41.8	56.6	64.7
33	0.14	0.22	0.31	0.42	0.55	0.69	0.85	1.02	1.21	1.41	1.62	1.86	2.10	2.36	2.63	2.92	3.22	3.53	3.85	4.19	6.04	8.15	9.65	10.4	12.9	15.5	18.1	27.0	42.5	57.5	65.7
34	0.14	0.22	0.32	0.43	0.56	0.70	0.86	1.03	1.22	1.43	1.65	1.88	2.13	2.40	2.67	2.96	3.27	3.58	3.91	4.25	6.14	8.27	9.80	10.6	13.1	15.7	18.4	27.4	43.1	58.4	66.7
35	0.14	0.22	0.32	0.44	0.57	0.71	0.87	1.05	1.24	1.45	1.67	1.91	2.16	2.43	2.71	3.01	3.31	3.64	3.97	4.32	6.22	8.39	9.94	10.7	13.3	15.9	18.7	27.8	43.7	59.2	67.7
36	0.14	0.23	0.33	0.44	0.57	0.72	0.89	1.06	1.26	1.47	1.70	1.94	2.19	2.47	2.75	3.05	3.36	3.69	4.03	4.38	6.31	8.51	10.0	10.9	13.5	16.2	18.9	28.2	44.4	60.1	68.6
37	0.15	0.23	0.33	0.45	0.58	0.73	0.90	1.08	1.28	1.49	1.72	1.97	2.22	2.50	2.79	3.09	3.41	3.74	4.08	4.44	6.40	8.63	10.2	11.0	13.6	16.4	19.2	28.5	45.0	60.9	69.6
38	0.15	0.23	0.33	0.45	0.59	0.74	0.91	1.09	1.29	1.51	1.74	1.99	2.25	2.53	2.83	3.13	3.45	3.79	4.14	4.50	6.49	8.74	10.3	11.2	13.8	16.6	19.4	28.9	45.6	61.7	70.5
39	0.15	0.24	0.34	0.46	0.60	0.75	0.92	1.11	1.31	1.53	1.77	2.02	2.28	2.57	2.86	3.17	3.50	3.84	4.19	4.56	6.57	8.86	10.4	11.3	14.0	16.8	19.7	29.3	46.2	62.5	71.4
40	0.15	0.24	0.34	0.47	0.60	0.76	0.93	1.12	1.33	1.55	1.79	2.04	2.31	2.60	2.90	3.21	3.54	3.89	4.24	4.61	6.65	8.97	10.6	11.5	14.2	17.0	19.9	29.7	46.8	63.3	72.3
41	0.15	0.24	0.35	0.47	0.61	0.77	0.94	1.14	1.35	1.57	1.81	2.07	2.34	2.63	2.94	3.25	3.59	3.94	4.30	4.67	6.74	9.08	10.7	11.6	14.4	17.2	20.2	30.1	47.3	64.1	73.2
42	0.16	0.25	0.35	0.48	0.62	0.78	0.96	1.15	1.36	1.59	1.83	2.09	2.37	2.66	2.97	3.29	3.63	3.98	4.35	4.73	6.82	9.19	10.8	11.8	14.5	17.4	20.4	30.4	47.9	64.9	74.1
43	0.16	0.25	0.36	0.48	0.63	0.79	0.97	1.16	1.38	1.61	1.86	2.12	2.40	2.69	3.01	3.33	3.67	4.03	4.40	4.78	6.90	9.30	11.0	11.9	14.7	17.7	20.7	30.8	48.5	65.6	75.0
44	0.16	0.25	0.36	0.49	0.63	0.80	0.98	1.18	1.39	1.63	1.88	2.14	2.43	2.73	3.04	3.37	3.72	4.08	4.45	4.84	6.98	9.41	11.1	12.0	14.9	17.9	20.9	31.1	49.0	66.4	75.9
45	0.16	0.25	0.36	0.49	0.64	0.81	0.99	1.19	1.41	1.65	1.90	2.17	2.45	2.76	3.08	3.41	3.76	4.12	4.50	4.89	7.06	9.52	11.2	12.2	15.1	18.1	21.2	31.5	49.6	67.2	76.7
46	0.16	0.26	0.37	0.50	0.65	0.82	1.00	1.20	1.43	1.66	1.92	2.19	2.48	2.79	3.11	3.45	3.80	4.17	4.55	4.95	7.14	9.62	11.4	12.3	15.2	18.3	21.4	31.8	50.1	67.9	77.6
47	0.17	0.26	0.37	0.51	0.66	0.82	1.01	1.22	1.44	1.68	1.94	2.22	2.51	2.82	3.14	3.48	3.84	4.21	4.60	5.00	7.21	9.73	11.5	12.4	15.4	18.5	21.6	32.2	50.7	68.6	78.4
48	0.17	0.26	0.38	0.51	0.66	0.83	1.02	1.23	1.46	1.70	1.96	2.24	2.53	2.85	3.18	3.52	3.88	4.26	4.65	5.06	7.29	9.83	11.6	12.6	15.5	18.7	21.9	32.5	51.2	69.4	79.3
49	0.17	0.27	0.38	0.52	0.67	0.84	1.03	1.24	1.47	1.72	1.98	2.26	2.56	2.88	3.21	3.56	3.92	4.30	4.70	5.11	7.37	9.93	11.7	12.7	15.7	18.9	22.1	32.9	51.8	70.1	80.1
50	0.17	0.27	0.38	0.52	0.68	0.85	1.04	1.26	1.49	1.73	2.00	2.29	2.59	2.91	3.24	3.59	3.96	4.35	4.75	5.16	7.44	10.0	11.8	12.8	15.9	19.0	22.3	33.2	52.3	70.8	80.9
51	0.17	0.27	0.39	0.53	0.68	0.86	1.05	1.27	1.50	1.75	2.02	2.31	2.61	2.94	3.27	3.63	4.00	4.39	4.79	5.21	7.52	10.1	12.0	13.0	16.0	19.2	22.5	33.5	52.8	71.5	81.7
52	0.17	0.27	0.39	0.53	0.69	0.87	1.06	1.28	1.52	1.77	2.04	2.33	2.64	2.96	3.31	3.67	4.04	4.43	4.84	5.26	7.59	10.2	12.1	13.1	16.2	19.4	22.7	33.9	53.3	72.2	82.5
53	0.18	0.28	0.40	0.54	0.70	0.88	1.07	1.29	1.53	1.79	2.06	2.35	2.66	2.99	3.34	3.70	4.08	4.47	4.89	5.31	7.66	10.3	12.2	13.2	16.3	19.6	23.0	34.2	53.8	72.9	83.3
54	0.18	0.28	0.40	0.54	0.70	0.88	1.09	1.31	1.54	1.80	2.08	2.38	2.69	3.02	3.37	3.74	4.12	4.52	4.93	5.36	7.73	10.4	12.3	13.3	16.5	19.8	23.2	34.5	54.3	73.6	84.1
55	0.18	0.28	0.40	0.55	0.71	0.89	1.10	1.32	1.56	1.82	2.10	2.40	2.71	3.05	3.40	3.77	4.16	4.56	4.98	5.41	7.80	10.5	12.4	13.5	16.6	20.0	23.4	34.8	54.8	74.3	84.8
56	0.18	0.28	0.41	0.55	0.72	0.90	1.11	1.33	1.57	1.84	2.12	2.42	2.74	3.08	3.43	3.80	4.19	4.60	5.02	5.46	7.88	10.6	12.5	13.6	16.8	20.2	23.6	35.1	55.3	74.9	85.6
57	0.18	0.29	0.41	0.56	0.72	0.91	1.11	1.34	1.59	1.85	2.14	2.44	2.76	3.10	3.46	3.84	4.23	4.64	5.07	5.51	7.95	10.7	12.6	13.7	16.9	20.3	23.8	35.4	55.8	75.6	86.4
58	0.18	0.29	0.41	0.56	0.73	0.92	1.12	1.35	1.60	1.87	2.16	2.46	2.79	3.13	3.49	3.87	4.27	4.68	5.11	5.56	8.01	10.8	12.8	13.8	17.1	20.5	24.0	35.8	56.3	76.3	87.1
59	0.19	0.29	0.42	0.57	0.74	0.92	1.13	1.36	1.61	1.88	2.17	2.48	2.81	3.16	3.52	3.90	4.30	4.72	5.16	5.61	8.08	10.9	12.9	13.9	17.2	20.7	24.2	36.1	56.8	76.9	87.9
60	0.19	0.29	0.42	0.57	0.74	0.93	1.14	1.38	1.63	1.90	2.19	2.50	2.83	3.18	3.55	3.94	4.34	4.76	5.20	5.65	8.15	10.9	13.0	14.1	17.4	20.9	24.4	36.4	57.3	77.6	88.6

Length(m)	Slope (%)																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	25	30	33.3	35	40	45	50	66.6	100	150	200
60	0.19	0.29	0.42	0.57	0.74	0.93	1.14	1.38	1.63	1.90	2.19	2.50	2.83	3.18	3.55	3.94	4.34	4.76	5.20	5.65	8.15	10.9	13.0	14.1	17.4	20.9	24.4	36.4	57.3	77.6	88.6
70	0.20	0.32	0.46	0.62	0.80	1.01	1.24	1.49	1.76	2.05	2.37	2.71	3.06	3.44	3.84	4.25	4.69	5.14	5.62	6.11	8.81	11.8	14.0	15.2	18.8	22.5	26.4	39.3	61.9	83.8	95.7
80	0.22	0.34	0.49	0.66	0.86	1.08	1.32	1.59	1.88	2.20	2.53	2.89	3.27	3.68	4.10	4.55	5.01	5.50	6.00	6.53	9.41	12.6	15.0	16.2	20.1	24.1	28.2	42.0	66.1	89.6	102.
90	0.23	0.36	0.52	0.70	0.91	1.14	1.40	1.69	2.00	2.33	2.69	3.07	3.47	3.90	4.35	4.82	5.32	5.83	6.37	6.92	9.98	13.4	15.9	17.2	21.3	25.6	29.9	44.6	70.2	95.0	108.
100	0.24	0.38	0.55	0.74	0.96	1.21	1.48	1.78	2.10	2.46	2.83	3.23	3.66	4.11	4.59	5.08	5.61	6.15	6.71	7.30	10.5	14.1	16.8	18.2	22.5	27.0	31.6	47.0	74.0	100.	114.
120	0.27	0.42	0.60	0.81	1.05	1.32	1.62	1.95	2.30	2.69	3.10	3.54	4.01	4.50	5.02	5.57	6.14	6.74	7.35	8.00	11.5	15.5	18.4	19.9	24.6	29.5	34.6	51.5	81.0	109.	125.
140	0.29	0.45	0.65	0.88	1.14	1.43	1.75	2.10	2.49	2.91	3.35	3.83	4.33	4.87	5.43	6.02	6.63	7.28	7.94	8.64	12.4	16.7	19.8	21.5	26.6	31.9	37.4	55.6	87.5	118.	135.
160	0.31	0.48	0.69	0.94	1.21	1.53	1.87	2.25	2.66	3.11	3.58	4.09	4.63	5.20	5.80	6.43	7.09	7.78	8.49	9.23	13.3	17.9	21.2	23.0	28.4	34.1	39.9	59.4	93.6	126.	144.
180	0.33	0.51	0.73	0.99	1.29	1.62	1.99	2.39	2.82	3.30	3.80	4.34	4.91	5.52	6.16	6.82	7.52	8.25	9.01	9.79	14.1	19.0	22.5	24.4	30.2	36.2	42.4	63.0	99.2	134.	153.
200	0.35	0.54	0.77	1.05	1.36	1.71	2.09	2.52	2.98	3.47	4.01	4.58	5.18	5.82	6.49	7.19	7.93	8.70	9.50	10.3	14.8	20.0	23.7	25.7	31.8	38.1	44.7	66.4	104.	141.	161.
225	0.37	0.57	0.82	1.11	1.44	1.81	2.22	2.67	3.16	3.69	4.25	4.85	5.49	6.17	6.88	7.63	8.41	9.22	10.0	10.9	15.7	21.2	25.2	27.3	33.7	40.5	47.4	70.5	111.	150.	171.
250	0.39	0.61	0.87	1.17	1.52	1.91	2.34	2.81	3.33	3.89	4.48	5.12	5.79	6.50	7.25	8.04	8.87	9.72	10.6	11.5	16.6	22.4	26.5	28.8	35.5	42.6	49.9	74.3	117.	158.	180.
275	0.41	0.64	0.91	1.23	1.59	2.00	2.45	2.95	3.49	4.07	4.70	5.37	6.07	6.82	7.61	8.44	9.30	10.2	11.1	12.1	17.4	23.5	27.8	30.2	37.3	44.7	52.4	77.9	122.	166.	189.
300	0.43	0.66	0.95	1.28	1.66	2.09	2.56	3.08	3.65	4.26	4.91	5.61	6.34	7.13	7.95	8.81	9.71	10.6	11.6	12.6	18.2	24.5	29.1	31.5	38.9	46.7	54.7	81.4	128.	173.	198.
325	0.44	0.69	0.99	1.34	1.73	2.18	2.67	3.21	3.80	4.43	5.11	5.83	6.60	7.42	8.27	9.17	10.1	11.0	12.1	13.1	18.9	25.5	30.3	32.8	40.5	48.6	56.9	84.7	133.	180.	206.
350	0.46	0.72	1.03	1.39	1.80	2.26	2.77	3.33	3.94	4.60	5.30	6.06	6.85	7.70	8.59	9.52	10.4	11.5	12.5	13.6	19.7	26.5	31.4	34.0	42.1	50.5	59.1	87.9	138.	187.	214.
375	0.48	0.74	1.06	1.44	1.86	2.34	2.87	3.45	4.08	4.76	5.49	6.27	7.09	7.97	8.89	9.85	10.8	11.9	13.0	14.1	20.3	27.4	32.5	35.2	43.5	52.2	61.2	91.0	143.	194.	221.
400	0.49	0.77	1.10	1.48	1.92	2.42	2.96	3.56	4.21	4.92	5.67	6.47	7.33	8.23	9.18	10.1	11.2	12.3	13.4	14.6	21.0	28.3	33.6	36.4	45.0	54.0	63.2	94.0	148.	200.	228.
425	0.51	0.79	1.13	1.53	1.98	2.49	3.05	3.67	4.34	5.07	5.84	6.67	7.55	8.48	9.46	10.4	11.5	12.6	13.8	15.0	21.7	29.2	34.6	37.5	46.4	55.6	65.1	96.9	152.	206.	235.
450	0.52	0.81	1.16	1.57	2.04	2.56	3.14	3.78	4.47	5.21	6.01	6.87	7.77	8.73	9.74	10.7	11.9	13.0	14.2	15.4	22.3	30.1	35.6	38.6	47.7	57.2	67.0	99.7	156.	212.	242.
475	0.54	0.84	1.20	1.62	2.10	2.63	3.23	3.88	4.59	5.36	6.18	7.05	7.98	8.97	10.0	11.0	12.2	13.4	14.6	15.9	22.9	30.9	36.6	39.6	49.0	58.8	68.9	102.	161.	218.	249.
500	0.55	0.86	1.23	1.66	2.15	2.70	3.31	3.98	4.71	5.50	6.34	7.24	8.19	9.20	10.2	11.3	12.5	13.7	15.0	16.3	23.5	31.7	37.5	40.7	50.3	60.3	70.6	105.	165.	224.	255.
550	0.58	0.90	1.29	1.74	2.25	2.83	3.47	4.18	4.94	5.76	6.65	7.59	8.59	9.65	10.7	11.9	13.1	14.4	15.7	17.1	24.6	33.2	39.4	42.7	52.7	63.3	74.1	110.	173.	234.	268.
600	0.60	0.94	1.35	1.82	2.36	2.96	3.63	4.36	5.16	6.02	6.94	7.93	8.97	10.0	11.2	12.4	13.7	15.0	16.4	17.8	25.7	34.7	41.1	44.6	55.1	66.1	77.4	115.	181.	245.	280.
650	0.63	0.98	1.40	1.89	2.45	3.08	3.78	4.54	5.37	6.27	7.23	8.25	9.34	10.4	11.7	12.9	14.3	15.6	17.1	18.6	26.8	36.1	42.8	46.4	57.3	68.8	80.5	119.	188.	255.	291.
700	0.65	1.02	1.45	1.96	2.54	3.20	3.92	4.71	5.57	6.50	7.50	8.57	9.69	10.8	12.1	13.4	14.8	16.2	17.7	19.3	27.8	37.5	44.4	48.1	59.5	71.4	83.6	124.	195.	265.	302.
750	0.68	1.05	1.51	2.03	2.63	3.31	4.06	4.88	5.77	6.73	7.77	8.87	10.0	11.2	12.5	13.9	15.3	16.8	18.3	20.0	28.8	38.8	46.0	49.8	61.6	73.9	86.5	128.	202.	274.	313.
800	0.70	1.09	1.55	2.10	2.72	3.42	4.19	5.04	5.96	6.95	8.02	9.16	10.3	11.6	12.9	14.3	15.8	17.4	19.0	20.6	29.7	40.1	47.5	51.5	63.6	76.3	89.4	132.	209.	283.	323.
850	0.72	1.12	1.60	2.16	2.80	3.52	4.32	5.19	6.14	7.17	8.27	9.44	10.6	12.0	13.3	14.8	16.3	17.9	19.5	21.2	30.7	41.3	49.0	53.1	65.6	78.7	92.1	137.	215.	292.	333.
900	0.74	1.15	1.65	2.23	2.89	3.63	4.45	5.34	6.32	7.38	8.51	9.71	10.9	12.3	13.7	15.2	16.8	18.4	20.1	21.9	31.5	42.5	50.4	54.6	67.5	81.0	94.8	141.	222.	300.	343.
950	0.76	1.19	1.69	2.29	2.96	3.72	4.57	5.49	6.49	7.58	8.74	9.98	11.2	12.6	14.1	15.6	17.2	18.9	20.7	22.5	32.4	43.7	51.8	56.1	69.3	83.2	97.4	144.	228.	308.	352.
1000	0.78	1.22	1.74	2.35	3.04	3.82	4.69	5.63	6.66	7.78	8.97	10.2	11.5	13.0	14.5	16.0	17.7	19.4	21.2	23.0	33.2	44.8	53.1	57.6	71.1	85.3	99.9	148.	234.	316.	361.
1100	0.82	1.28	1.82	2.46	3.19	4.01	4.91	5.91	6.99	8.15	9.41	10.7	12.1	13.6	15.2	16.8	18.6	20.4	22.2	24.2	34.9	47.0	55.7	60.4	74.6	89.5	104.	155.	245.	332.	379.
1200	0.86	1.33	1.91	2.57	3.33	4.19	5.13	6.17	7.30	8.52	9.82	11.2	12.6	14.2	15.9	17.6	19.4	21.3	23.2	25.3	36.4	49.1	58.2	63.0	77.9	93.5	109.	162.	256.	347.	396.
1300	0.89	1.39	1.98	2.68	3.47	4.36	5.34	6.42	7.60	8.87	10.2	11.6	13.2	14.8	16.5	18.3	20.2	22.1	24.2	26.3	37.9	51.1	60.6	65.6	81.1	97.3	113.	169.	266.	361.	412.
1400	0.92	1.44	2.06	2.78	3.60	4.52	5.55	6.67	7.89	9.20	10.6	12.1	13.7	15.4	17.1	19.0	20.9	23.0	25.1	27.3	39.4	53.1	62.9	68.1	84.2	101.	118.	175.	276.	374.	428.
1500	0.96	1.49	2.13	2.88	3.73	4.68	5.74	6.90	8.16	9.52	10.9	12.5	14.1	15.9	17.7	19.7	21.7	23.8	26.0	28.2	40.7	54.9	65.1	70.5	87.1	104.	122.	182.	286.	388.	443.
1600	0.99	1.54	2.20	2.97	3.85	4.84	5.93	7.13	8.43	9.84	11.3	12.9	14.6	16.4	18.3	20.3	22.4	24.6	26.8	29.2	42.1	56.7	67.2	72.8	90.0	108.	126.	188.	296.	400.	457.
1700	1.02	1.59	2.27	3.06	3.97	4.98	6.11	7.35	8.69	10.1	11.6	13.3	15.1	16.9	18.9	20.9	23.1	25.3	27.6	30.1	43.4	58.5	69.3	75.1	92.8	111.	130.	193.	305.	413.	471.
1800	1.05	1.63	2.33	3.15	4.08	5.13	6.29	7.56	8.94	10.4	12.0	13.7	15.5	17.4	19.4	21.5	23.8	26.1	28.5	30.9	44.6	60.2	71.3	77.2	95.5	114.	134.	199.	313.	425.	485.
1900	1.08	1.68	2.40	3.24	4.20	5.27	6.46	7.77	9.19	10.7	12.3	14.1	15.9	17.9	20.0	22.1	24.4	26.8	29.2	31.8	45.9	61.8	73.2	79.3	98.1	117.	137.	204.	322.	436.	498.
2000	1.11	1.72	2.46	3.32	4.30	5.41	6.63	7.97	9.43	11.0	12.6	14.4	16.3	18.4	20.5	22.7	25.0	27.5	30.0	32.6	47.0	63.4	75.1	81.4	100.	120.	141.	210.	330.	448.	511.
2100	1.13	1.76	2.52	3.40	4.41	5.54	6.79	8.17	9.66	11.2	13.0	14.8	16.7	18.8	21.0	23.3	25.7	28.1	30.7	33.4	48.2	65.0	77.0	83.4	103.	123.	144.	215.	339.	459.	524.
2200	1.16	1.81	2.58	3.48	4.51	5.67	6.95	8.36	9.89	11.5	13.3	15.1	17.1	19.3	21.5	23.8	26.3	28.8	31.5	34.2	49.3	66.5	78.8	85.4	105.	126.	148.	220.	347.	469.	536.
2300	1.19	1.85	2.64	3.56	4.62	5.80	7.11	8.55	10.1	11.7	13.6	15.5	17.5	19.7	22.0	24.4	26.9	29.5	32.2	35.0	50.5	68.0	80.6	87.3	107.	129.	151.	225.	354.	480.	548.
2400	1.21	1.89	2.70	3.64	4.72	5.92	7.26	8.73	10.3	12.0	13.8	15.8	17.9	20.1	22.4	24.9	27.4	30.1	32.9	35.7	51.5	69.5	82.3	89.2	110.	132.	154.	230.	362.	490.	560.
2500	1.24	1.93	2.75	3.71	4.81	6.05	7.41	8.91	10.5	12.3	14.1	16.1	18.3	20.5	22.9	25.4	28.0	30.7	33.5	36.5	52.6	70.9	84.0	91.0	112.	135.	158.	235.	370.	500.	572.
2600	1.26	1.96	2.81	3.79	4.91	6.17	7.56	9.09	10.7	12.5	14.4	16.5	18.6	20.9	23.4	25.9	28.6	31.3	34.2	37.2	53.6	72.3	85.7	92.8	114.	137.	161.	239.	377.	510.	583.
2700	1.29	2.00	2.86	3.86	5.00	6.28	7.70	9.26	10.9	12.7	14.7	16.8	19.0	21.3	23.8	26.4	29.1	31.9	34.9	37.9	54.7	73.7	87.3	94.6	116.	140.	164.	244.	384.	520.	594.
2800	1.31	2.04	2.91	3.93	5.09	6.40	7.84	9.43	11.1	13.0	15.0	17.1	19.3	21.7	24.2	26.9	29.6	32.5	35.5	38.6	55.7	75.1	88.9	96.3	119.	142.	167.	248.	391.	530.	605.
2900	1.33	2.07	2.96	4.00	5.18	6.51	7.98	9.60	11.3	13.2	15.2	17.4	19.7	22.1	24.7	27.4	30.2	33.1	36.1	39.3	56.7	76.4	90.5	98.0	121.	145.	170.	253.	398.	539.	616.
3000	1.36	2.11	3.02	4.07	5.27	6.62	8.12	9.76	11.5	13.4	15.5	17.7	20.0	22.5	25.1	27.8	30.7	33.7	36.7	40.0	57.6	77.7	92.0	99.7	123.	147.	173.	257.	405.	548.	626.
3500	1.46	2.28	3.26	4.40	5.70	7.15	8.77	10.5	12.4	14.5	16.7	19.1	21.6	24.3	27.1	30.1	33.1	36.4	39.7	43.2	62.2	83.9	99.4	107.	133.	159.	187.	278.	437.	592.	677.
4000	1.57	2.44	3.48	4.70	6.09	7.65	9.38	11.2	13.3	15.5	17.9	20.4	23.1	26.0	29.0	32.1	35.4	38.9	42.4	46.1	66.5	89.7	106.	115.	142.	170.	199.	297.	468.	633.	723.
4500	1.66	2.59	3.69	4.99	6.46	8.11	9.95	11.9	14.1	16.5	19.0	21.7	24.5	27.6	30.8	34.1	37.6	41.2	45.0	48.9	70.6	95.2	112.	122.	151.	181.	212.	315.	496.	672.	767.
5000	1.75	2.73	3.89	5.26	6.81	8.55	10.4	12.6	14.9	17.3	20.0	22.9	25.9	29.1	32.4	35.9	39.6	43.5	47.5	51.6	74.4	100.	118.	128.	159.	190.	223.	332.	523.	708.	809.
5500	1.84	2.86	4.08	5.51	7.14	8.97	11.0	13.2	15.6	18.2	21.0	24.0	27.1	30.5	34.0	37.7	41.6	45.6	49.8	54.1	78.0	105.	124.	135.	166.	200.	234.	348.	548.	743.	848.
6000	1.92	2.99	4.27	5.76	7.46	9.37	11.4	13.8	16.3	19.0	21.9	25.0	28.3	31.8	35.5	39.4	43.4	47.6	52.0	56.5	81.5	109.	130.	141.	174.	209.	244.	364.	573.	776.	886.
6500	2.00	3.11	4.44	5.99	7.76	9.75	11.9	14.3	17.0	19.8	22.8	26.1	29.5	33.1	37.0	41.0	45.2	49.6	54.1	58.8	84.8	114.	135.	146.	181.	217.	254.	379.	596.	807.	922.
7000	2.07	3.23	4.61	6.22	8.06	10.1	12.4	14.9	17.6	20.5	23.7	27.1	30.6	34.4	38.4	42.5	46.9	51.4	56.2	61.1	88.1	118.	140.	152.	188.	225.	264.	393.	619.	838.	957.

(SOIL CONSERVATION SERVICE 1977)

Vegetal canopy: Type & height of raised canopy[2]	Canopy cover[3] %	Type[4]	Cover that contacts the surface: Percent ground cover 0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
No appreciable canopy		G	.450	.388	.325	.263	.200	.175	.150	.125	.100	.086	.071	.057	.042	.035	.028	.020	.013	.011	.008	.006	.003
		W	.450	.398	.345	.293	.240	.218	.195	.173	.150	.135	.120	.105	.090	.078	.067	.055	.044	.035	.027	.019	.011
Canopy of tall weeds or short brush (0.5 m fall ht.)	25	G	.360	.313	.265	.218	.170	.150	.130	.110	.090	.077	.064	.051	.038	.032	.025	.019	.012	.010	.008	.005	.003
		W	.360	.320	.280	.240	.200	.183	.165	.148	.130	.118	.106	.094	.082	.072	.062	.051	.041	.034	.026	.019	.011
	50	G	.260	.228	.195	.163	.130	.115	.100	.085	.070	.061	.053	.044	.035	.029	.024	.018	.012	.010	.008	.005	.003
		W	.260	.235	.210	.185	.160	.148	.135	.123	.110	.101	.093	.084	.075	.066	.057	.048	.039	.032	.025	.018	.011
	75	G	.170	.153	.135	.118	.100	.090	.080	.070	.060	.053	.046	.038	.031	.026	.021	.016	.011	.009	.007	.005	.003
		W	.170	.158	.145	.133	.120	.113	.105	.098	.090	.084	.079	.073	.067	.060	.053	.045	.038	.031	.025	.018	.011
Appreciable brush or brushes (2m fall ht.)	25	G	.400	.345	.290	.235	.180	.158	.135	.113	.090	.078	.065	.053	.040	.033	.027	.020	.013	.011	.008	.006	.003
		W	.400	.355	.310	.265	.220	.200	.180	.160	.140	.126	.113	.099	.085	.074	.064	.053	.042	.034	.027	.019	.011
	50	G	.340	.295	.250	.205	.160	.141	.123	.104	.085	.073	.062	.050	.038	.032	.025	.019	.012	.010	.008	.005	.003
		W	.340	.303	.265	.228	.190	.175	.160	.145	.130	.118	.106	.093	.081	.071	.061	.051	.041	.034	.026	.019	.011
	75	G	.280	.245	.210	.175	.140	.125	.110	.095	.080	.069	.058	.047	.036	.030	.024	.018	.012	.010	.008	.005	.003
		W	.280	.253	.225	.198	.170	.158	.145	.133	.120	.109	.099	.088	.077	.068	.059	.049	.040	.033	.026	.018	.011
Trees but no appreciable low brush (4m fall ht.)	25	G	.420	.363	.305	.248	.190	.168	.145	.123	.100	.085	.071	.056	.041	.034	.027	.020	.013	.011	.008	.006	.003
		W	.420	.373	.325	.278	.230	.208	.185	.163	.141	.127	.114	.100	.087	.076	.065	.053	.042	.034	.027	.019	.011
	50	G	.390	.338	.285	.233	.180	.158	.135	.113	.090	.078	.065	.053	.040	.033	.027	.020	.013	.011	.008	.006	.003
		W	.390	.345	.300	.255	.210	.193	.175	.158	.140	.126	.113	.099	.085	.074	.064	.053	.042	.034	.027	.019	.011
	75	G	.360	.313	.265	.218	.170	.150	.130	.110	.090	.077	.065	.052	.039	.032	.026	.019	.012	.010	.008	.005	.003
		W	.360	.320	.280	.240	.200	.183	.165	.148	.130	.118	.107	.095	.083	.073	.062	.052	.041	.034	.026	.019	.011

[1]All values shown assume (1) random distribution of mulch or vegetation, and (2) mulch of appreciable depth where it exists. Idle land refers to land with undisturbed profiles for at least a period of three consecutive years. Also to be used for burned forest land and forest land that has been harvested less than 3 years ago.

[2]Average fall height of water drops from canopy to soil surface.

[3]Portion of total-area surface that would be hidden from view by canopy in a vertical projection (a bird's-eye view).

[4]G. Cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 inches deep. W. Cover at surface is mostly broadleaf herbaceous (as weeds with little lateral-root network near the surface), and/or undecayed residue.

EROSION POTENTIAL INDEX WORKSHEET

Road Location and Description

Ranger District: _____

Legal Location: L.S.D. _____ Section: _____ Township: _____ Range: _____ W ____ M

Disposition Number: _____

Constructed by: _____

Maintained by: _____

Creek/River Name: _____

Other Description: _____

Assessment Details

Erosion Potential Index: (Total of Column 10) _____

Date of Survey: (Y/M/D) _____ / _____ / _____

Conducted by: _____

Photos Available: Yes _____ No _____

Measurements and Calculations

1	2	3	4	5	6				7	8	9	10
Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2]	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
	Length	Slope Gradient			%	Grass or Weeds	%	Short brush Brush Trees	(m^2)			
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Erosion Potential Index (Sum of Column 10)												

NOTE: Abbreviations used: m - metres; m^2 = square metres; % = percent; Desc. = Description

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[5] Erosion Potential Index is calculated by multiplying Columns 7, 8 and 9.

Soil Conservation/Strategy

Description of Erosion Control Work Needed: _____

Recalculation of Measurements

1	2	3	4	5	6				7	8	9	10
Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2] (m^2)	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
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Sketch of Area

EROSION POTENTIAL INDEX WORKSHEET

Road Location and Description

Ranger District: _____

Legal Location: L.S.D. _____ Section: _____ Township: _____ Range: _____ W ____ M

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Creek/River Name: _____

Other Description: _____

Assessment Details

Erosion Potential Index: (Total of Column 10) _____

Date of Survey: (Y/M/D) _____ / _____ / _____

Conducted by: _____

Photos Available: Yes _____ No _____

Measurements and Calculations

1	2	3	4	5	6				7	8	9	10
Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2] (m^2)	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
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Soil Conservation/Strategy

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Sketch of Area

EROSION POTENTIAL INDEX WORKSHEET

Road Location and Description

Ranger District: _____

Legal Location: L.S.D. _____ Section: _____ Township: _____ Range: _____ W ____ M

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Other Description: _____

Assessment Details

Erosion Potential Index: (Total of Column 10) _____

Date of Survey: (Y/M/D) _____ / _____ / _____

Conducted by: _____

Photos Available: Yes _____ No _____

Measurements and Calculations

1	2	3	4	5	6				7	8	9	10
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Soil Conservation/Strategy

Description of Erosion Control Work Needed: _____

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Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2] (m^2)	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
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Sketch of Area

EROSION POTENTIAL INDEX WORKSHEET

Road Location and Description

Ranger District: _____

Legal Location: L.S.D. _____ Section: _____ Township: _____ Range: _____ W ____ M

Disposition Number: _____

Constructed by: _____

Maintained by: _____

Creek/River Name: _____

Other Description: _____

Assessment Details

Erosion Potential Index: (Total of Column 10) _____

Date of Survey: (Y/M/D) _____ / _____ / _____

Conducted by: _____

Photos Available: Yes _____ No _____

Measurements and Calculations

1	2	3	4	5	6				7	8	9	10
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Soil Conservation/Strategy

Description of Erosion Control Work Needed: _____

Recalculation of Measurements

1	2	3	4	5	6				7	8	9	10
Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2] (m^2)	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
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Sketch of Area

Soil Conservation/Strategy

Description of Erosion Control Work Needed: _____

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Sketch of Area

EROSION POTENTIAL INDEX WORKSHEET

Road Location and Description

Ranger District: _____

Legal Location: L.S.D. _____ Section: _____ Township: _____ Range: _____ W ____ M

Disposition Number: _____

Constructed by: _____

Maintained by: _____

Creek/River Name: _____

Other Description: _____

Assessment Details

Erosion Potential Index: (Total of Column 10) _____

Date of Survey: (Y/M/D) _____ / _____ / _____

Conducted by: _____

Photos Available: Yes _____ No _____

Measurements and Calculations

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Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2] (m^2)	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
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EROSION POTENTIAL INDEX WORKSHEET

Road Location and Description

Ranger District: _____

Legal Location: L.S.D. _____ Section: _____ Township: _____ Range: _____ W ____ M

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Measurements and Calculations

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Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2] (m^2)	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
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Soil Conservation/Strategy

Description of Erosion Control Work Needed: _____

Recalculation of Measurements

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Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2] (m^2)	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
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Sketch of Area

EROSION POTENTIAL INDEX WORKSHEET

Road Location and Description

Ranger District: _____

Legal Location: L.S.D. _____ Section: _____ Township: _____ Range: _____ W ____ M

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Assessment Details

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Measurements and Calculations

1	2	3	4	5	6				7	8	9	10
Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2] (m^2)	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
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Soil Conservation/Strategy

Description of Erosion Control Work Needed: _____

Recalculation of Measurements

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Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2] (m^2)	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
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Sketch of Area

EROSION POTENTIAL INDEX WORKSHEET

Road Location and Description

Ranger District: _____

Legal Location: L.S.D. _____ Section: _____ Township: _____ Range: _____ W ____ M

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Assessment Details

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Soil Conservation/Strategy

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Sketch of Area

EROSION POTENTIAL INDEX WORKSHEET

Road Location and Description

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Legal Location: L.S.D. _____ Section: _____ Township: _____ Range: _____ W ____ M

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Soil Conservation/Strategy

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9												
10												
11												
12												
13												
14												
15												
Erosion Potential Index (Sum of Column 10)												

Sketch of Area

EROSION POTENTIAL INDEX WORKSHEET

Road Location and Description

Ranger District: _____

Legal Location: L.S.D. _____ Section: _____ Township: _____ Range: _____ W ____ M

Disposition Number: _____

Constructed by: _____

Maintained by: _____

Creek/River Name: _____

Other Description: _____

Assessment Details

Erosion Potential Index: (Total of Column 10) _____

Date of Survey: (Y/M/D) _____ / _____ / _____

Conducted by: _____

Photos Available: Yes _____ No _____

Measurements and Calculations

1	2	3	4	5	6				7	8	9	10
Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2] (m^2)	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
	Length	Slope Gradient			%	Grass or Weeds	%	Short brush Brush Trees				
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
Erosion Potential Index (Sum of Column 10)												

NOTE: Abbreviations used: m - metres; m^2 = square metres; % = percent; Desc. = Description

[1] If a portion of the panel surface has a canopy of brush or trees, refer to Table 2 for additional details.

[2] Panel area is calculated by multiplying Side A Length and Side B Length.

[3] Length/Slope Factor is taken directly from Table 1 using the measurements of Side A.

[4] Vegetation Management Factor is taken directly from Table 2 using ground cover percentage and vegetation type.

[5] Erosion Potential Index is calculated by multiplying Columns 7, 8 and 9.

Soil Conservation/Strategy

Description of Erosion Control Work Needed: _____

Recalculation of Measurements

1	2	3	4	5	6				7	8	9	10
Panel	Side A		Side B Length	Panel Desc. Cut, Fill, or Level	Panel Ground Cover[1]				Panel Area[2] (m^2)	Length/ Slope Factor[3]	Vegetation Management Factor[4]	Erosion Potential Index[5]
	Length	Slope Gradient			%	Grass or Weeds	%	Short brush Brush Trees				
1												
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11												
12												
13												
14												
15												
Erosion Potential Index (Sum of Column 10)												

Sketch of Area

Additional worksheets may be obtained by contacting:

Watershed Section
Forest Land Use Branch
9920 - 108 Street
Edmonton, Alberta
T6C 1K8

(403) 469-5600

N.L.C. - B.N.C.
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